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STUDIES ON FABRICATION AND TESTING OF BIOFIBER REINFORCED POLYMER MATRIX COMPOSITES

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ABSTRACT

Polymers find a wide variety of applications in day to day life because of their unique properties such as high strength to weight ratio, lightness, economy, biodegradability etc. The composites with natural fibers as reinforcement are increasing interest for the industries and have many applications in aerospace, automotive industry, sports, marine, and military. The present work is aimed at the study of the mechanical properties of the polymer composite. The work comprises of fabrication of polymer composite followed by testing its mechanical properties. The analysis for the strength of the sisal fiber reinforced polymer composites has been made with weight fraction and random orientation. The percentage of sisal fiber is varied from 24% to 36% in steps of 6%. The sisal fiber composites were prepared by hand layup technique. The specimens were cut according to ASTM standards by water jet machining and the variation in the mechanical properties with respect to fiber content in the composite was studied. From the studies made it is found that the increase in the percentage of sisal fiber by weight in the composite shown significant improvement with respect to mechanical properties and which may replace some of the conventional materials used in automobiles.

KEYWORDS: Natural Fiber Composite, Sisal Fiber, Resin, Hardener & Hand Layup Process

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Original Article

1. INTRODUCTION

Over the last few years, composite materials have been dominant emerging materials. The volume and number of applications of composite materials have grown steadily, penetrating and conquering new markets intensively. While composites have already proven their worth as lightweight materials, the current effort is to make them cost effective. Composite materials have been a promising material over a period of time. The application of this is increasing steadily and establishing new market interests. As it has already proved its worth as lightweight materials, the present study is aimed at making them more economical. The composites which have reinforcements as natural fiber has more interest for the industries and have many applications in aerospace, automotive industry, sports, marine, and military. The composites industry has started recognizing that the commercial applications of composites offer much larger business opportunities than the aerospace sector due to the sheer size of transportation industries. Hence the composite applications from aircraft to other application uses has become prominent in the past few decades.

Conventional and traditional fiber reinforced composites are made of glass fibers and carbon fibers which are incorporated into polymers, composites have good mechanical properties but these materials pollute the

environment because of non-degradability of synthetic fibers. The world is seeing a change, an increase in the pollution level has slowed down the change towards good and it's a high time that world community works towards this challenge. There is a need for use of renewable sources to reduce the amount of pollution. Thus use of bio fibers as a replacement to synthetic and harmful fibers is becoming a trend. Bio fibers are hence facing a renaissance, not only for earlier industrial products but also for the production of new types of materials and products. The use of natural or plant fiber reinforced composite is progressing with time. This is because of advantages such as low cost, ease of availability, lightweight etc. The important and exclusive properties of the natural composite are its renewability and biodegradability. These materials are eco-friendly and these composites also provide an alternative way to deal with agricultural residue.

In the present work, sisal fiber composite specimens are prepared by varying the weight percentage of sisal fiber using the hand layup method. These specimens were cut using the water jet machining to required ASTM standards.

The composite specimens prepared are subjected to different mechanical tests such as tensile, bending, hardness, impact. The electrical property of the sisal fiber composite has been studied using the breakdown voltage of solid insulation as a parameter.

2. MATERIALS AND METHODS

In the present work, hand layup technique was used for the preparation of composite with sisal fibers as the reinforcement material, L-12 as the resin and K-6 as the hardener.

2.1. Preparation of Fibers

The sisal fibers come under organic classification i.e. biodegradable and it further comes under plant species and the fiber is processed from the stem. Since the fibers come from the stem, less energy is required to process the leaves to get the fibers. The leaves are soaked in water for about an 8-10 days, after which the leaves being beaten on a stone to remove the extraneous matter, and there the separated fiber is washed, dried in sunlight and baled. The sisal plant has a (7-10) year life-span and typically produces around 200 commercially usable leaves. Each which will have an average of around 1100 fibers. The fibers account for only around 4% of the plant by weight. Decortication is another means of extracting fibers where leaves are crushed, beaten, and brushed away by a rotating wheel set with blunt knives. Depending on the weather, the fibers will dry in two to three days under sunlight. Proper drying plays a vital role as the quality of fibers depends heavily on moisture content.

2.2. Preparation of Composite

In the hand lay-up process, an aluminum sheet metal is used to make the mould of the dimension 300X300X3 (mm). The corners of the mould are left open so that the excess mixture of resin and hardener drains out of the mould.

After the extraction of the sisal fiber, it is treated with NaOH solution of 10% concentration and left for an hour. This treatment cleans the fiber from dust and particulates. Alkaline treatment also reduces the hemicellulose content of the fiber and the moisture absorption of the sisal fiber. The tensile strength of the fiber is found to increase after the alkaline treatment. The resin (L-12) and hardener (K-6) used are in the ratio of 10:1 for proper curing, thus 30 ml of hardener is added to 300ml of resin to make a laminate of required dimension. In the fabrication process of composite initially the surface of the mould is cleaned and then a thin sheet of plastic is laid on the mould followed by spraying a layer of releasing agent (wax) on the sheet and allowing the wax to semi-dry. The next step is to pour the mixture of resin and

hardener in the mould, now the fibers are impregnated in the mould. This process is continued untill the required thickness of the laminate is obtained.

The Waterjet machining is used to cut the laminates of (300X300X3) mm into smaller specimens according to the ASTM standards.

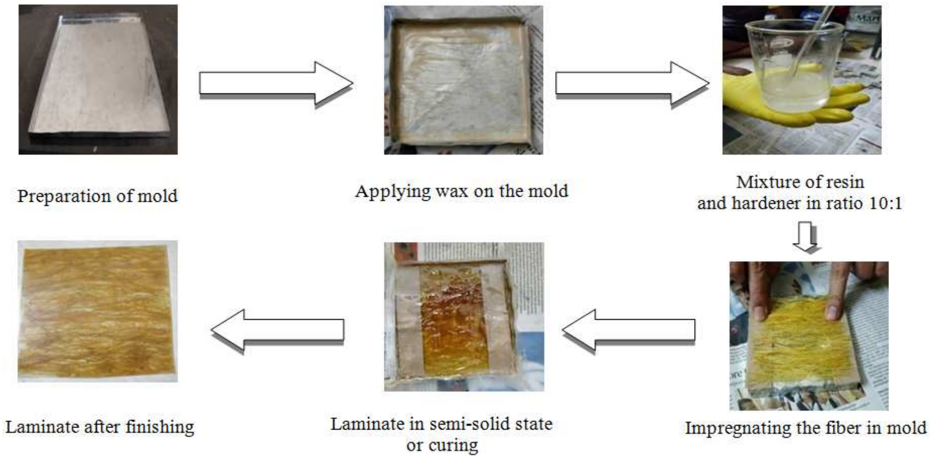

Figure 1: General Flowchart of the Composite Preparation Process

2.3. Preparation of Test Specimens

Specimens to the required shape and dimensions according to the ASTM standards were prepared using waterjet machining as shown below.

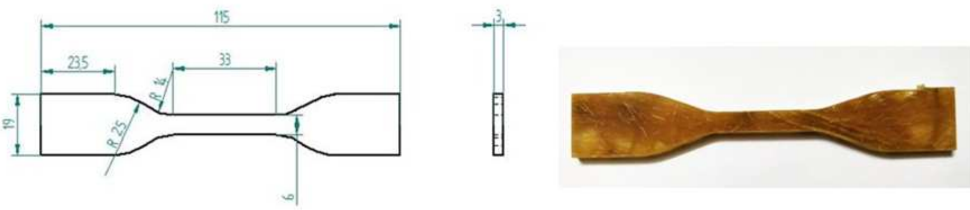

Figure 2: Test Specimen for Tension as per (ASTM D638-03)

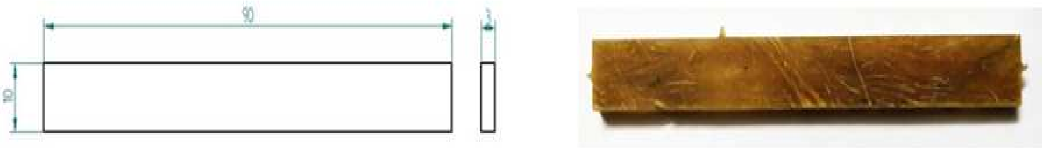

Figure 3: Test Specimen for Bending as per ASTM D3039

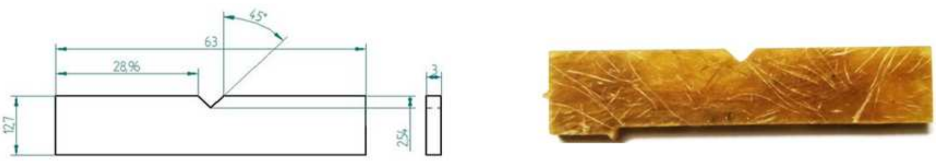

Figure 4: Test Specimen for Impact Test as per ASTM D256-06

Figure 5: Test Specimen for Hardness (30X30 mm)

Figure 6: Electrical Test Specimen (80X80 mm)

3. RESULTS AND DISCUSSIONS

3.1. Tensile Test

Figure 7: Stress v/s Strain

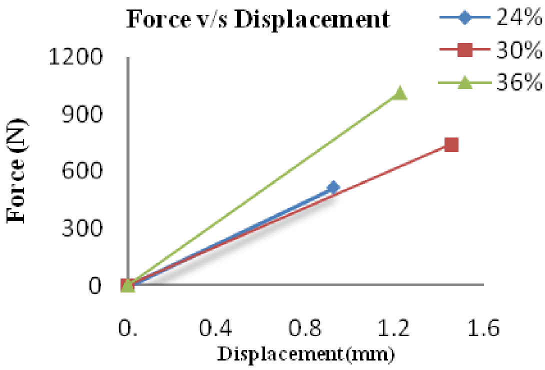

Figure 8: Force v/s Displacement

From Figure 7 it is evident that tensile strength has increased with the percentage increase in the addition to the fibers. It is clear from the figure that among the samples tested the fiber reinforced composite with 36% fiber addition by weight could bear a load of 1011 N at an extension of 1.22 mm with ultimate strength and Young's modulus of 56.16 MPa and 1.519 GPa respectively.

3.2. Bending Test

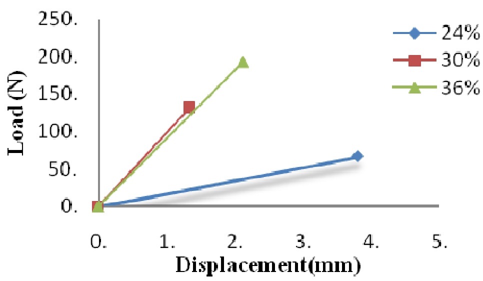

Figure 9: Force v/s Displacement

Figure 9 shows the bending load v/s displacement curve for different composites. The figure reveals that the bending properties are affected by the weight of fiber in the composite and the material with 36% fiber withstands the highest value of bending load equal to 192 N and yields more strength if compared with other two samples.

3.3. Impact Test

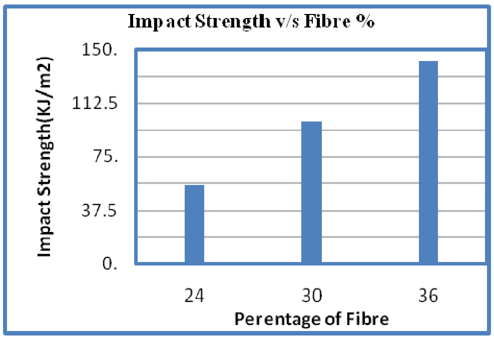

Figure 10: Force v/s Displacement

It is observed from the Figure 10 that the impact strength of composite laminate with36% sisal fiber reinforcement is higher than the other laminates. Laminate of 24% and 30% exhibit poor impact strength due to the poor interfacial bonding between fabrics and matrix as well as fabrics pull out.

3.4. Hardness Test

The result for hardness using the Rockwell hardness testing machine was found to be **95HRC** where C stands for the scale used for measurement. The Hardness test conducted wasn't accurate as the top layer of composite is made of resin and gives a different value for every sample.

3.5. Breakdown Voltage of Solid Insulation

The breakdown voltage of the laminates was found to be decreased with the increase in fiber percentage as seen from figure 11.

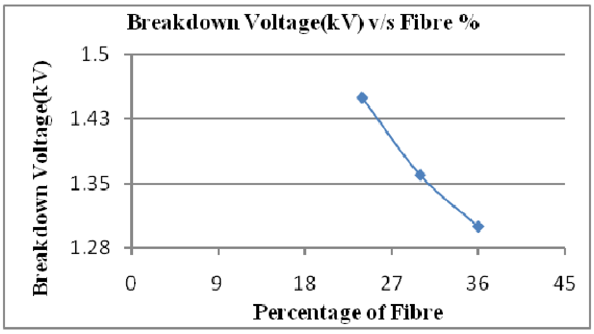

Figure 11: Breakdown Strength Comparison

4. CONCLUSIONS

The following conclusions were made from the tests conducted on sisal fiber for various mechanical properties.

- Sisal fibers were successfully reinforced in the mixture of resin and hardener giving a strong laminate.
- The variation in the mechanical properties with respect to the fiber content in the composite was studied.
- It was found that the peak load increases with the increase in the content of the fiber in the composite during both tensile and bending test.
- The maximum displacement was highest in the specimen with 30% fiber weight.

- The impact strength of the specimens increased with the increase in the percentage of fiber in the composite.
- A breakdown voltage of solid insulation was found to be decreasing with the increase in the fiber percentage in the composite
- A hardness of the specimens couldn't be accurately determined because of unavailability of the Shore durometer hardness tester, however, the test conducted on the specimens using Rockwell hardness testing machine showed negligible change in the hardness with respect to the fiber percentage in the composite.

REFERENCES

1. *Dittenber DB, Ganga Rao HVS (2012) Critical review of recent publications on use of natural composites in infrastructure. Compos A 43(8):1419–1429*
2. *Sanjay MR, Arpitha GR, Yogesha B et al (2016) Applications of natural fibers and its composites: an overview. Natur Resour 7: 108–114*
3. *Koronis G, Silva A, Fontul M (2013) Green composites: a review of adequate materials for automotive applications. Compos B 44: 120–127*
4. *Sanjay MR, Arpitha GR, Yogesha B (2015) Study on Mechanical Properties of Natural - Glass Fiber Reinforced Polymer Hybrid Composites: A Review. Mater Tod Proc 2(4–5):2959–2967*
5. *Jawaid M, Abdul Khalil HPS (2011) Cellulosic/synthetic fiber reinforced polymer hybrid composites: a review. Carbohydr Polym 86:1–18*
6. *Ramesh M, Palanikumar K, Hemachandra RK (2013) Mechanical property evaluation of sisal–jute–glass fiber reinforced polyester composites. Compos B 48:1–9*
7. *Reddy, A. C. Low and High Temperature Micromechanical Behavior of BN/3003 Aluminum Alloy Nanocomposites.*
8. *Chand N, Joshi SK (1994) Temperature dependence of dielectric behavior of sisal fiber. J Mater Sci Lett 13:156–158*
9. *Ochi S (2008) Mechanical properties of kenaf fibers and kenaf/PLA composites. Mech Mater 40:446–452*
10. *Ratna Prasad AV, Mohana RK (2011) Mechanical properties of natural fiber reinforced polyester composites: Jowar, sisal and bam- boo. Mater Des 32:4658–4663*
11. *Ho M-p, Lau K-t (2012) Design of an impact resistant glass fiber/ epoxy composites using short silk fibers. Mater Des 35:664–669*
12. *Braga RA, Magalhaes PAA Jr (2015) Analysis of the mechanical and thermal properties of jute and glass fiber as reinforcement epoxy hybrid composites. Mater Sci Eng C 56:269–27314. Velmurugan R, Manikandan V (2007) Mechanical properties of palmyra/glass fiber hybrid composites. Composites A38:2216–2226*
13. *Sreekala MS, Jayamol G, Kumaran MG et al (2002).The mechanical performance of hybrid phenol–formaldehyde–based composites reinforced with glass and oil palm fibers. Compos Sci Technol 62:339–353*
14. *Jarukumjorn K, Suppakarn N (2009) Effect of glass fiber hybridization on properties of sisal fiber – polypropylene composites. Composites B40 (7):623–627*
15. *Mishra S, Mohanty AK, Drzal LT et al (2003) Studies on mechanical performance of biofiber/glass reinforced polyester hybrid composites. Compos Sci Technol 63:1377–1385*
16. *KM, A. F., & Varghese, S. (2014). Behavioural Study of Steel Fiber and Polypropylene Fiber Reinforced Concrete.*

17. *Sneha LP, Venkateswara RM, Kiran Kumar VV et al (2015) Evaluation of mechanical and tribological properties of bamboo–glass hybrid fiber reinforced polymer composite. J Ind Text 46(1):1–16*

18. *Panthapulakkal S, Sain M (2007) Injection–molded short hemp fiber/glass fiber reinforced polypropylene hybrid composites – mechanical, water absorption and thermal properties. J Appl Polym Sci 103:2432–2441*

19. *Raj, R.G., Kokta, B.V., Maldas, D. and Daneault, C. (1989). Use of wood fibers in thermoplastics. VII. The effect of coupling agents in polyethylene-wood fiber composites. J. Appl. Polym. Sci. 37:1089-1103*

20. *Maldas, D. and Kokta, B.V. (1995). Composites of Chlorinated Polyethylene wood fibers. J. Reinf. Plast. Compos. 14: 458-470*

21. *Simpson, R. and Selke, S. (1991). Composite materials from recycled multilayer polypropylene bottles and wood fibers. Polym. Prepr. Amer. Chem. Soc., Div. Polym. Chem. 32:148-149.*

22. *Yun, K., Hirano, M., Yanase, S., & Ohya, Y. (2016). New Fabrication Method Suggestion of the Motor Core Using Ceramic Precursor.*

23. *Sain, M.M. and Kokta, B.V. (1994).Polyolefin- wood filler composite. I. Performance of mphenylene bismaleimide-modified wood fiber in polypropylene composites. J. Appl. Polym. Sci.Natural fiber reinforced composites 142 54:1545-1559*

24. *Kokta, B.V., Chen, R., Daneault, C. and Valade, J.L. (1983).Use of wood fibers in thermoplastics composites. Polym. Compos. 4:229-23*